PRE OPERATIVE PLANNING
How to work up a Nonunion and Potential Infection

If you could order ONE x-ray study for the pre-op planning of a tibial nonunion...it would be???

- CT scan to determine if its hypertrophic vs atrophic
- MRI to elucidate infection status...infected nonunion??
- Long alignment film
- PET/CT to determine infection AND biologic status of nonunion
- 4 cone down views of tibia, A/P, lateral, and 2 oblique views

NON UNION CHARACTERIZATION

- DETERMINE TRUE PLANE OF DEFORMITY
  - METHODOLOGY OF CORRECTION
    - OSTEOTOMY POSSIBLE? WITH REASONABLE EXPOSURE
  - LEVEL OF DEFORMITY
    - LOCATION OF DEFORMITY
    - LEVEL OF OSTEOTOMY
  - BIOLOGY OF NON-UNION
    - HYPERTROPHIC vs ATROPHIC
ANALYSIS OF NONUNION

- BIOLGy OF NONUNION
  - HYPERTROPHIC
  - ATROPHIC
  - SEPTIC

BIOMECHANICAL CHARACTERIZATION

- EVALUATE “STABILITY” OF CONSTRUCT
  - MOTION ARTIFACT
  - BROKEN...LOOSE SCREWS
  - OSTEOYSIS
  - CALLOUS...NO CALLOUS???
  - PRIMARY FRACTURE LINE ORIENTATION
- CT EVALUATION.....helps in this regard
OTA MINI SYMPOSIA
2014
Managing Nonunion: Theory and Practice

Moderator: Christopher G. Moran, FRCS
Faculty: Pierre Guy, MD;
R. Malcolm Smith, MD
John J. Wixted, MD

STRESS / STRAIN

□ COMMINUTED FRACTURES NEVER FORM A COMMINUTED NONUNION????
□ AS FRACTURES HEAL…. A DELAYED HEALING SEGMENT SEES MORE STRAIN….THUS CHANGES THE HEALING CURVE FOR THAT SEGMENT
□ REDUCING STRAIN ………ALLOW SEGMENT TO HEAL…….
HEALING POTENTIAL

TIME

Fx Healed

NON UNION

6-9 MONTHS

STRAIN

HEALING POTENTIAL

TIME

Fx Healed

NON UNION

6-9 MONTHS

Decrease strain (add stability)

UNION

6-9 MONTHS

Decrease strain (add stability)
Augment healing potential (add graft)

CRUSH INJURY WITH COMPROMISED TISSUE DISTAL 1/3 TIBIA
WHEN IN DOUBT..OR TO BUY TIME.......GET A CT

6 WEEKS post lag screw
PRINCIPLES OF Rx
HYPERTROPHIC NON-UNION
- MECHANICAL STABILIZATION
- "BIOLOGIC” SURGICAL APPROACH
- LIMITED NEED FOR BONE GRAFT ADJUVANTS

PRINCIPLES OF Rx
ATROPHIC NON-UNION
- MECHANICAL STABILIZATION
- PROVIDE BIOLOGIC STIMULUS
  - BMAC GRAFT + DBM
  - INDUCTIVE FACTORS (BMP’s, PDGF, PRP, DBM)
  - AUTOGRRAFT – RIA, ILIAC CREST
  - VASCULARIZED TRANSPLANT
  - BONE TRANSPORT

SMALL DEFECTS
LARGE DEFECTS
ANALYSIS OF NON-UNION

- PREVIOUS TREATMENT
  - NON-OPERATIVE
  - EXTERNAL FIXATION
  - IM NAILING
  - ORIF
    - (must R/O infection)

DEFORMITY CHARACTERIZATION

- DETERMINE MAXIMAL DEFORMITY
  - METHODOLOGY OF CORRECTION
  - ACUTE vs GRADUAL CORRECTION
    - NERVE INJURY > 15° ACUTE CORRECTION UNLESS SHORTENING AT SAME TIME
  - CANAL MALALIGNMENT
    - IM NAILING POSSIBLE?
    - REVISION PLATING???
ANALYSIS OF NON-UNION

DEFORMITY
- ANGULATION
- MALROTATION
  - CT EVALUATION
- LEG LENGTH DESCREPANCY
- TRANSLATION
  - RELATIVE ALIGNMENT MEDULLARY CANALS

A/P ANGULATION

LATERAL ANGULATION
OBLIQUE PLANE DEFORMITY

MAGNITUDE & DIRECTION

TRUE PLANE OF DEFORMITY
DEFORMITY ANALYSIS

- MECHANICAL AXIS DEVIATION
  - FRONTAL PLANE DEFORMITIES
  - LEVEL DETERMINED BY INTERSECTION OF MECHANICAL AXIS FEMUR / TIBIA

DEFORMITY ANALYSIS

- CORA
  - CENTER OF ROTATION AND ANGULATION...
    - INTERSECTION OF ANATOMIC AXIS
    - INTERSECTION OF MECHANICAL AXIS

RELATIONSHIP OF ANGULATION TO TRANSLATION
DEFORMITY ANALYSIS

If the CORA is not at the same level as the apex of the deformity... you have a translational deformity as well.
PROBLEMS

With any translation.....ALWAYS HAS TO BE A COMPENSATORY MAL ROTATION
PROBLEMS

- Malrotation 20 degrees

Problems

- Leg length 1in.
- Translation 100%
- Angulation 20 degrees
- Mechanical axis deviation lateral
- Malrotation 20 degrees
- Hypertrophic
- Infection
Hypertrophic, translation, malrotation, angulation, LLD

ANALYSIS OF INFECTION

- PREVIOUS TREATMENT
  - NON-OPERATIVE
  - EXTERNAL FIXATION
  - IM NAILING
  - ORIF
  - HOW TO R/O INFECTION???
The workup for a “suspected” infected non-union should routinely include:

- Indium labeled WBC scan
- Intra-op path (WBC per HPF)
- Gallium subtraction bone scan
- MRI with and without contrast
- PET / CT to determine infection AND biologic status of nonunion
- WBC, WSR, CRP
- WBC, WSR, CRP, intra-op path

PRE-OP STUDIES SPECIFIC FOR INFECTION?

- RADIOGRAPHIC STUDIES
  - PLAIN FILMS
  - CT SCANS
  - MRI
  - NUCLEAR MEDICINE
    - BONE SCAN
    - WBC / INDIUM LABELED
    - GALLIUM
BONE SCAN
INDIUM SCAN
GALLIUM SCAN

MRI...SENSITIVE......
...BUT NOT SPECIFIC FOR
INFECTION

PRE - OP - INTRA - OP
STUDIES

LABORATORY STUDIES
- WBC
- WSR
- CRP

PATHOLOGY
- SINUS TRACT CULTURE
- INTRA-OP GRAM STAIN
- INTRA-OP BIOPSY
WHAT SHOULD I ORDER?

PERI-OPERATIVE DIAGNOSIS OF INFECTION IN NONUNIONS / ACUTE Fx

- PRE OP BLOOD WORK
  - WBC
  - CRP
  - ESR
- COMBINED INDIUM WBC / BONE SCAN
- INTRA OP gm STAIN
- INTRA OP DEEP CULTURES

TORNETTA et al...AAGS 2011

WHAT DO THE RESULTS MEAN?

- PPV...POSITIVE PREDICTIVE VALUE
  - PROBABILITY THAT THE pt. HAS THE INFECTION COMPARED TO ALL THE PTS THAT ARE INFECTED
WHAT DO THE RESULTS MEAN?

- NPV...NEGATIVE PREDICTIVE VALUE
  - PROBABILITY THAT THE pt. DOES NOT HAVE INFECTION ..... COMPARED TO THE ALL PTS THAT ARE NOT INFECTED

WBC SCAN RESULTS

- PPV......50%
- NPV.....72%

CRP RESULTS

- PPV......54%
- NPV.....75%
ESR RESULTS

- PPV......58%
- NPV.....80%

WBC > 11,000

- PPV......50%
- NPV.....70%

PATH WBC'S >3 HPF

- PPV......40%
- NPV.....81%
RESULTS

- NO SINGLE TEST WAS INDEPENDENTLY ACCURATE
- COMBINATION OF RISK FACTORS USED TO CALCULATE OVERT INFECTION RISK

RESULTS

- RISK FACTORS
  - ELEVATED WBC, ESR, CRP, AND + SCAN
  - FOR 0, 1, 2, 3 RISK FACTORS BEING +
    - PPV...0-22%, 1-36%, 2-57%, 3-83%

RESULTS

- ELIMINATED NUCLEAR SCANS
- WBC, ESR, AND CRP
- PPV...0-25%, 1-27%, 2-58%, 3-100%
RECOMMEND

- SIMPLE BLOOD TEST ‘s
  - CRP, ESR, WBC’’s
  - INTRA-OPERATIVE WBC/HPF


FACTORS AFFECTING BONE HEALING

- PHYSIOLOGIC
  - STERIODS
  - DIABETES
  - HYPERVITAMINOSIS A & D
  - CASTRATION
  - ANEMIA
  - RADIATION
  - Ca++ METABOLISM

BRINKER et al

FACTORS AFFECTING BONE HEALING

- SMOKING!!!!
  - NICOTINE...DIRECT TOXIN TO OSTEOLASTS
  - INHIBIT COLLAGEN SYNTHESIS
  - DECREASE OXYGEN CARRYING CAPACITY
  - PERIPHERAL VASCULAR EFFECT
MAKE PROBLEM LIST

- CHARACTERIZE NONUNION TYPE
  - BIOLOGIC
  - BIO-MECHANICAL
- DETERMINE DEFORMITY PARAMETERS
- EVALUATE POTENTIAL INFECTION STATUS
- METABOLIC QUALIFIERS

Infected distal nonunion with LLD, malrotation, deformity, mechanical axis deviation
PRE-OP PROBLEM LIST

- BONE LOSS
- INFECTED
- DEFORMITY
- LEG LENGTH DESCREEPANCY
WHEN TREATING A NON UNION.......IT’S PROBABLY BETTER NOT TO SCREW UP IF YOU DON’T HAVE TO....... Vert Mooney....Chair U.T. Southwest 1987